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Providing Meteorological and Hydrographic Information via AIS Application-Specific Messages: Challenges and Opportunities

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Abstract: AIS Application-Specific Messages (ASMs) transmitted in binary format will be increasingly used to digitally communicate maritime safety/security information between participating vessels and shore stations. This includes time-sensitive meteorological and hydrographic (met/hydro) information that is critical for safe vessel transits and efficient ports/waterways management. IMO recently published a new Safety-of-Navigation Circular (SN.1/Circ.289) that includes a number of meteorological and hydrographic message applications and data parameters. While there are no specific display standards for AIS ASMs on shipborne or shore-based systems, IMO Has also issued general guidance for the presentation/display of ASMs (SN.1/Circ.290). It includes specific mention of conforming to the e-Navigation concept-of-operation. For any new IHO S-57 or S-100-related product specifications dealing with dynamic met/hydro information, IHO and its Member States should use the same data content fields and parameters that are defined in IMO SN.1/Circ.289. Also, there is a need to consider the implications of IMO guidance regarding the presentation/display of AIS ASMs on ECDIS.

Introduction

e-Navigation is a recent IMO initiative that aims to integrate existing/new shipboard and shore-based navigational tools into an “all embracing” system. Defined as:

...the harmonised collection, integration, exchange, presentation and analysis of maritime information onboard and ashore by electronic means to enhance berth to berth navigation and related services, for safety and security at sea and protection of the marine environment”

the goal of e-Navigation is to provide an infrastructure that will enable seamless information transfer onboard ship, between ships, ship-to-shore, and between shore authorities [1]. Core elements include high-integrity electronic positioning, electronic navigational charts (ENCs) and improved system functionality towards reducing human error. In particular, this means actively engaging the mariner in the process of navigation while preventing distraction and overburdening.

To date, the primary focus of IHO Member States has been to complete ENC coverage for major shipping routes. However, e-Navigation has other implications for the hydrographic community. In particular, this includes the increasing use of AIS Application-Specific Messages (ASMs) to provide dynamic and real-time meteorological and hydrographic (met/hydro) information. However, to do so there will be some challenges including:

- 1) Developing a suitable process to convert existing met/hydro information into AIS ASMs.
- 2) Establishing the necessary infrastructure/coordination for AIS ASM provision and broadcast.
- 3) Determining the best means for displaying AIS ASMs on ECDIS and other shipborne equipment.

Background

Automatic Identification System (AIS) is an autonomous and continuous broadcast system that exchanges maritime safety/security information between participating vessels and shore stations. AIS operates in the VHF maritime mobile band using Time Division Multiple Access (TDMA) technology. Chapter V of the 1974 SOLAS Convention [2] required mandatory carriage of AIS equipment for all types and sizes of SOLAS Convention vessels by 31 December 2004. As defined in the IMO Performance Standards for AIS [3], AIS enables both ships and maritime safety administrations to effectively track the movement of vessels in coastal waters. In addition, AIS can contribute to safety-of-navigation and protection of the environment by providing additional navigation-related information in the form of AIS ASMs. This includes meteorological and hydrographic data, carriage of dangerous cargos, safety and security zones, status of aids-to-navigation, and other ports/waterway safety information. This information is broadcast from shore-side AIS Base Stations or specially equipped buoys to ships that are at-sea or in port.

AIS Application Specific Messages

ITU-R M. Recommendation 1371-1 [4], provides the basis for the use of AIS binary messages. These messages contain application-specific binary data which can be created by an application on the transmitting side and interpreted and displayed by another application on the receiving end. Proper interpretation depends on the use of an agreed data structure. This means that conformance to internationally-agreed binary message (now referred to as “AIS Application-Specific Messages) standards is essential. While it is IMO that defines the content of AIS Messages, it is ITU-R M.1371-1 that specifies the technical characteristic and the structure of the binary AIS messages.

In May 2004, IMO issued SN/Circ.236 on “Guidance on the Application of AIS binary Messages” [5]. SN/Circ.236 defines the data content for seven (7) types of AIS Binary Message Applications. These were to be tested and evaluated in conjunction with existing shipborne navigation systems during a trial period lasting four (4) years. This included the AIS Minimum Keyboard Display (MKD), radar, ECDIS, and Integrated Navigation System (INS) equipment, and well as Electronic Charting Systems (ECS) and Portable Piloting Units (PPUs).

On 2 June 2010, a new Safety of Navigation Circular, (SN.1/Circ.289), “Guidance on the Use of AIS Application-specific Messages” was issued by IMO [6]. This circular significantly expanded the scope of AIS ASMs, and will supercede SN/Circ.236 on 1 January 2013. Table 1 provides a comparison of existing applications contained in SN/Circ.236 and the revised/new messages in the new SN.1/Circ.289. AIS Application-Specific Messages (ASMs) that involve met/hydro information are high-lighted in grey.

IMO SN/Circ.236			IMO SN.1/Circ.289	
Appl No.	Message Name	FI	Message Name	FI
1	Meteorological/Hydrological	11	Meteorological and Hydrographic	11
2	Dangerous cargo indication	12	Dangerous cargo indication	25
3	Fairway closed	13	---	--
4	Tidal window	14	Tidal window	14
5	Extended ship static and voyage related data	15	Extended ship static and voyage related data	24
6	No. of persons onboard	16	No. of persons onboard	16
7	Pseudo-AIS targets	17	VTS-generated targets	17
			Clearance time to enter port	18
			Marine traffic signal	19
			Berthing data	20
			Weather report from ships	21
			Area Notice - broadcast	22
			Area Notice - addressed	23
			Environmental	26
			Route Information – broadcast	27
			Route Information – addressed	28
			Text Description – broadcast	29
			Text Description – addressed	30

Table 1 – Comparison of AIS Application-Specific Messages contained in IMO SN/Circ.236 and the revised/new messages contained in IMO SN.1/Circ.289.

The following is a brief description of those ASMs that are related to meteorological and hydrographic parameters.

Meteorological and Hydrological – This message provides a wide variety of met/hydro data including, wind speed/direction, visibility, tide/water levels, surface currents, wave and swell measurements, sea state, and ice. Initially developed by IALA, it is currently in wide use. Other than changing the name from Hydrological to Hydrographic, the information content in SN.1/Circ. 289 is unchanged from that of SN/Circ.236.

Tidal Window – This message is used to inform vessels about tidal windows which allow a vessel safe passage in a fairway or channel. In addition to date/time and location, information is also provided on current direction and speed. Similar to the Met/Hydro, this message is already in use. As such, the information content in SN.1/Circ.289 is unchanged from that of SN/Circ.236.

Weather Report from Ship to Other Ships – Developed by the World Meteorological Organization (WMO), this message is intended to provide observed weather information by a ship in transit to other vessels or to WMO. This includes present weather conditions related to visibility, wind, temperature, wave height and swell period/direction.

Area Notice (broadcast and addressed) - This message provides dynamic information concerning a specified geographic area, polyline or positions. It is used to provide pertinent time-critical navigation safety information to mariners or authorities, and not as a means to convey information already contained in official nautical charts or publications.

Environmental – Originally developed by the Radio Technical Commission for Maritime Services (RTCM), this message has a flexible design. It is more suited for some applications while the Met/Hydro message in SN/Circ.236 for other situations. Since transmission of various forms of met/hydro information via AIS ASMs is becoming more common, two different messages types are available depending on the particular situation. The Met/Hydro message is best suited for local transmission of information from several sensors at the same position. Alternatively, the Environmental message separates static data (e.g., station ID, location) from

dynamic sensor data. In some situations, it is possible to send same data content using fewer slots than the Met/Hydro message. This is particularly useful when broadcasting both forecast and “Nowcast” (i.e. continuously updated forecast) information.

Some key parameters and descriptions for these AIS ASMs contained in IMO SN.1/Circ.289 include:

<u>Table</u>	<u>Application</u>
1.1	Meteorological and hydrographic Data
3.1	Tidal window
10.1	Weather observation report – from ship to other ships
11.1 -3	Area notice broadcast and addressed
.5	Circle or point (e.g., endangered whales detected)
.6	Rectangle
.7	Sector
.8	Waypoint or polyline (e.g., for an ice boundary or storm front)
.9	Polygon
.11	Notice description (e.g., #99 - chart feature: shoal area)
12.1	Environmental
.2	Environmental message sensor report framework
.3	Environmental message sensor report types
.4	Sensor site location
.5	Station ID
.6	Wind report
.7	Water level report
.8	Current flow report: two-dimensions (x & y)
.9	Current flow report: 3-dimensionsl (x, y, & z)
.10	Horizontal current flow report
.11	Sea-state report
.12	Salinity report
.13	Weather report
.14	Air gap

Table 2 – Meteterological/Hydrograpic parameters and descriptions listed in IMO SN.1/Circ.289.

Regional Applications

In addition to the new IMO SN.1/Circ 289 standard, RTCM is developing a standard that defines the scope and content of AIS ASMs that are intended for both international and regional use. For international use, the RTCM standard provides further guidance/refinement on the use of AIS ASMs that have been published by IMO. This includes both IMO SN/Circ 236 and the SN.1/Circ.289. Applications intended for regional use include those that were developed for use in North America and other regions. In particular, the RTCM standard has a “Waterways Management” application that is not contained in either the IMO SN/Circ. 236 or the new SN.1/Circ.289.

The Draft *RTCM Standard [121xx.1] for AIS Binary Application-specific) Messages: International and Regional Use* is in the final stages of refinement. It is not the intent of RTCM to duplicate the IMO standard. Instead, describing the content and use of these messages can help facilitate the implementation process. Further, some of the messages contained in the SN.1/Circ.289 may require further refinement or clarification. Finally,

since it is not likely that IMO SN.1/Circ.289 will be revised by IMO for 4-5 years, the RTCM standard can be a means to address any errors or inconsistencies. Most likely, this will be performed by issuing an updated version of RTCM standard on a periodic basis (e.g., once a year).

Displaying AIS Application-specific Messages

In the near future, it is expected that AIS ASMs will be an important component of the e-Navigation concept-of-operations. In particular, AIS ASMs are one way (i.e., “how”) to achieve e-Navigation: *“the harmonized collection, integration, exchange, presentation and analysis of maritime information onboard and ashore by electronic means...”*. While the data format and content are reasonably well-defined, how AIS ASMs should be displayed is less clear.

Currently, SOLAS vessels are not required to have specific equipment capable of interpreting, processing, or displaying the information content of AIS ASMs. While the Minimum Keyboard Display (MKD) may be suitable for displaying text messages, it was never intended for the graphical display/presentation of AIS ASMs. However, several types of AIS ASMs are already being displayed on Electronic Chart Systems (ECS), Integrated Navigation Systems (INS), and Portable Piloting Units (PPUs), as well as at Port Authorities and Vessel Traffic Service (VTS) Centers.

In conjunction with issuing SN.1/Circ.289, IMO also issued *Guidance for the Presentation and Display of AIS Application-Specific Messages Information* (SN.1/Circ.290) [7]. This “guidance” was purposely general since it was felt that it was premature to propose specific presentation or display standards for AIS ASMs until further experience is gained. As such, IMO SN.1/Circ 290 provides some “guiding principles” that apply to displaying AIS ASMs both for shipborne equipment/systems (e.g., ECDIS, radar, & INS), as well as for shore-based systems (e.g., VTS Centre console):

1. Use **consistent** symbology across all displays.
2. **Uniqueness** – only one possible meaning.
3. **Non-ambiguous** – ability to determine differences (i.e. distinct).
4. **Intuitively obvious** – an easily recognized symbol, icon or pattern.
5. Have a **basic symbol** for different categories. Further attributes should be enhancements (not changes) to the basic symbol.

In concept, few would likely disagree with these principles. However, in practice it may be a challenge to achieve a consensus between providers and users (both shipborne and shore-based) as to what is really suitable or effective.

Currently, all shipboard equipment/systems installed on SOLAS vessels must conform to IMO Res. MSC.191(79), *“IMO Performance Standards for the Presentation of Navigation-related Information on Shipborne Displays”* [8] that was adopted in 2004. However, there are several types of shipborne equipment/systems including ECDIS, radar, and INS that were adopted prior to 2004 that will need to be reconsidered in terms of compliance with the over-arching MSC.191(79) standard. In addition, AIS ASMs represent an entirely new form of supplemental information that that was not previously known when MSC.191(79) was issued. Further, there are no specific standards related to the presentation/display of shore-based information (e.g., at a

VTs Center). However, under the e-Navigation concept-of-operations, standards that apply to the display of shipborne information should be suitable for shore-based displays as well.

IMO SN.1/Circ.290 lists four basic options for displaying AIS ASMs: alpha-numeric, graphical, symbol, and geo-spatial. Table 3 indicates which options would seem to be suitable for the met/hydro-related applications contained in IMO SN.1/Circ. 289.

Application	Alpha-numeric (text & numbers)	Graphical (time-series graph)	Symbol (or icon)	Geo-spatial (Point, line, or area)
Meteorological and Hydrographic	X	X	X	X
Tidal window	X	X	X	X
Weather Report from Ships	X			
Area Notice - broadcast	X	X		X
Area Notice - addressed	X	X	X	
Environmental	X	X	X	X

Table 3 – Basic options for displaying met/hydro AIS ASMs contained in IMO SN.1/Circ. 289.

AIS ASM Portrayal Examples

“Portrayal” is the process of representing or depicting (i.e., showing an example) of what is or could be. Figures 1 and 2 provide examples of how some of met/hydro can be portrayed. This includes alpha-numeric, graphs, symbols, and geographic (i.e., spatial) information.

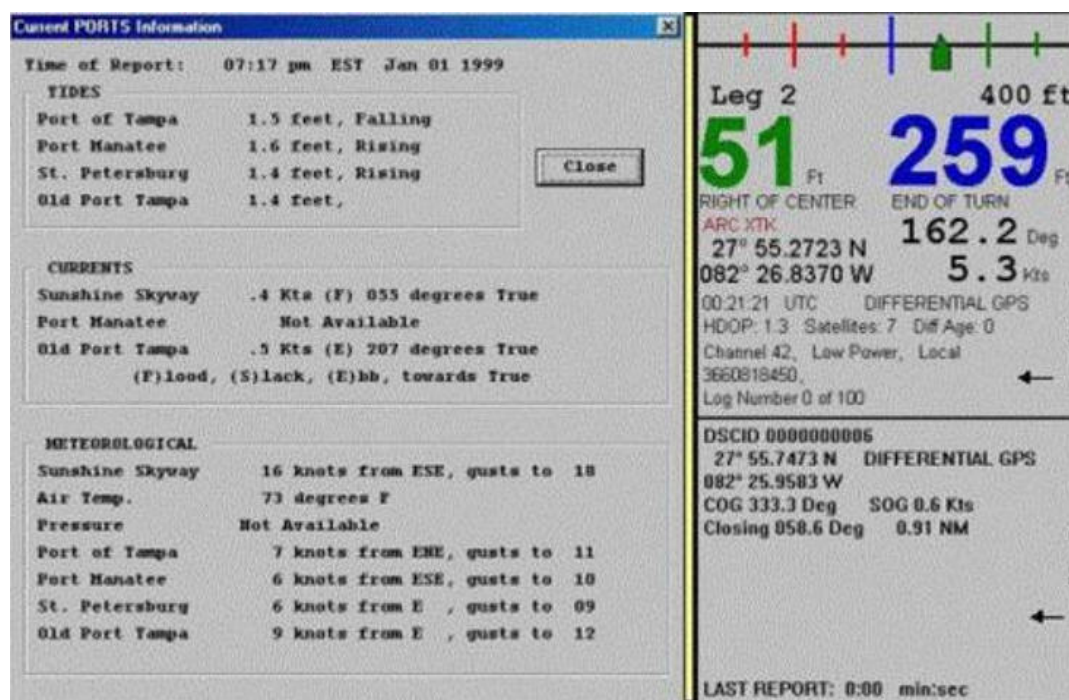


Figure 1 - An example of real-time alpha-numeric data pertaining to tidal changes, current flow velocity, and meteorological conditions in the Port of Tampa, FL. The data source is the NOAA Physical Oceanographic Real-time System (*PORTS*) that has been converted into an AIS ASM and transmitted from a USCG VTS Center. The information is displayed on Portable Pilot Unit (PPU) that is carried onboard vessels by Tampa Bay Pilots.

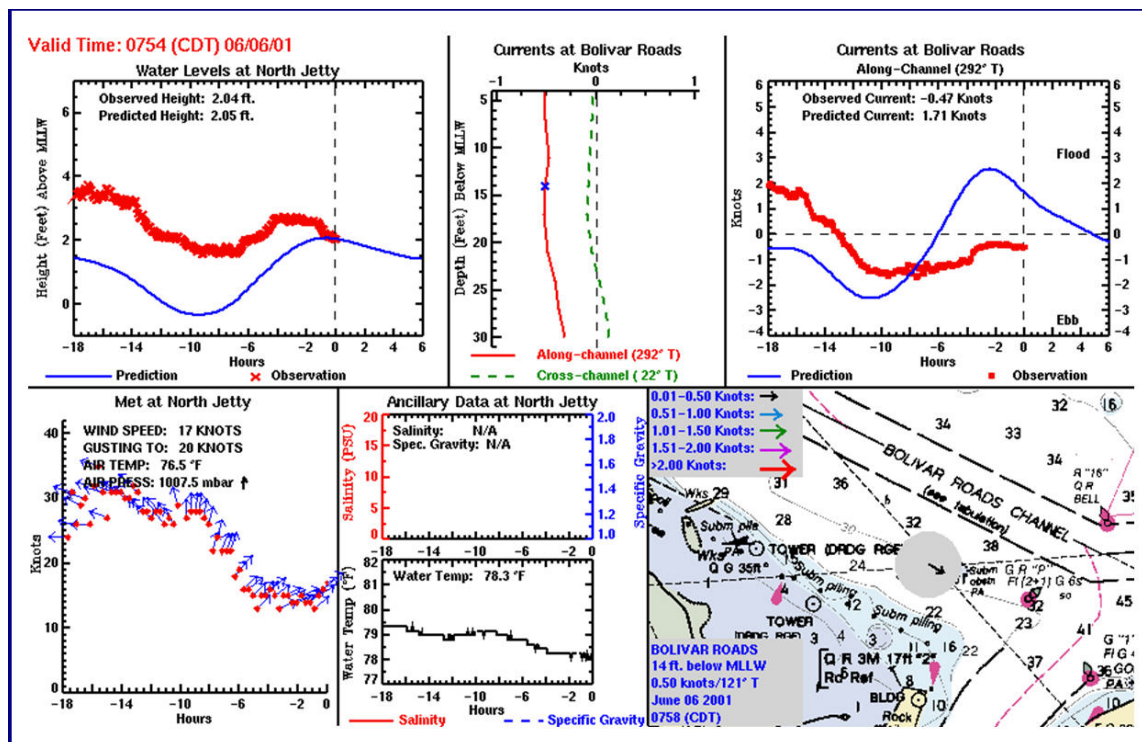


Figure 2 – A graphical display of both predicted and observed met/hydro NOAA *PORTS* data in Galveston, TX. While similar to alpha-numeric text in terms of data content, the information is displayed as a time-series graphs capable of depicting differences and trends (i.e., predicted vs. observed). This also includes alpha-numeric text that is displayed as an overlay on geographic data (a raster navigational chart).

Even with objective, clearly-defined data contents, what constitutes appropriate presentation or display is subjective and influenced by opinion or preference. As such, further testing and trials are needed to develop more specific guidelines on the presentation/display of AIS ASMs. This includes practical experience on the four basic means of displaying AIS ASMs: alpha-numeric, graphical (e.g., time-series graph), point, line, or polygon (e.g., area notice), and symbol or icon. In particular, testing is needed in regard to how AIS ASMs should be displayed on ECDIS in conjunction with chart-related information. This includes both information content, and amount of information to be displayed on ECDIS based on the current navigation situation (e.g., open ocean, coastal, approach, etc.) and the task-at-hand (e.g., grounding avoidance, collision avoidance, situational awareness, etc.). In addition, background color scheme is a further consideration.

Relationship to IHO Standards

Since its adoption 1998, IHO S-57 Edition 3.0/3.1 has been used almost exclusively for encoding Electronic Navigational Charts (ENCs) for use in Electronic Chart Display and Information Systems (ECDIS) [9]. More recently, Marine Information Overlays (MIOs) in S-57 format have been developed for both static and dynamic parameters [10].

The new IHO Geospatial Standard for Digital Hydrographic Data (S-100) [11] is intended to be used for the exchange of digital hydrographic data between hydrographic offices, and for the distribution of hydrographic data to manufacturers, mariners and other data users (e.g., environmental management organizations). It was developed so that the transfer of all forms of hydrographic data would take place in a consistent and uniform manner. A S-101 ENC Product Specification is under development and is planned to go into force in 2012 [12].

AIS ASMs are already in use, and this will likely increase. Ideally, AIS ASMs and IHO S-101 will be compatible in terms of complementary data content and format such that both can be used in ECDIS, INS, and PPU's. For IHO S-57 and S-100 related standards dealing with dynamic met/hydro information, consideration should be given to using the same data content fields and parameters that are defined in IMO SN.1/Circ.289. Further, additional consideration should be given toward how AIS ASMs will be displayed on ECDIS and other shipborne navigation systems such as INS. In this regard, IHO S-52 [13] will need to be reviewed in terms of how AIS ASMs would be displayed on a type-approved ECDIS in conjunction with chart-related colours and symbols.

Looking Ahead

The challenges associated with the use of AIS ASMs are more organizational than technical. Based on what has occurred in the past, it will be a difficult and time-consuming process to establish the necessary infrastructure for one government agency to convert met/hydro sensor data into a binary format, and then pass it to another agency to be broadcast via AIS base stations as an AIS ASM. Often times, different agencies have different ideas on what types of met/hydro data are important, and the level of detail or precision that is required. While most would agree on the need to provide met/hydro data, agreeing on the specific details regarding data parameters, formatting, and distribution can be problematic. To accomplish the process will require a fair amount of cooperation between intra- and inter-government agencies, equipment manufactures, and maritime user groups. While these organizational challenges may be difficult to overcome, significant benefits result when "harmonized" regional and/or international standards are implemented and used by all concerned.

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